Urban Tracking and Positioning System

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The Urban Tracking and Positioning System is a high-resolution urban tracking demonstration system similar to GPS but suitable for indoor use in locales such as buildings and caves. Indoor localization of radio devices is a daunting task due to the presence of severe multipath and low probability of a line-of-sight (LOS) signal between the transmitter and receiver. This harsh propagation environment for radio signals is due to the shadowing and reflections from walls and objects.

In FY2005 we built a set of high-accuracy ranging devices using ultra-wideband (UWB) RF signals and algorithms for position estimation. UWB signals are particularly suited for ranging because of their short duration, high-bandwidth pulses. Our ranging and positioning algorithms improve accuracy by addressing some of the known challenges in UWB localization. In FY2006 we expanded the capabilities of these units to support multiple masters and tag units operating in the same environment, offering true 3-D location capabilities to multiple receivers.

Project Goals

The goals of this project were to combine LLNL UWB radio hardware capable of collecting range measurements with LLNL software algorithms to perform the signal processing needed to recover the RF signatures in high-scattering environments. When combined, these technologies create a complete system capable of high-resolution geo-location in poor RF environments, such as urban areas or inside buildings, where traditional geo-location technologies such as GPS, are not available or do not yield sufficient accuracy.

Relevance to LLNL Mission

Several LLNL programs have an interest in the high strategic potential of urban tracking. Applications for high-accuracy systems for use in complex

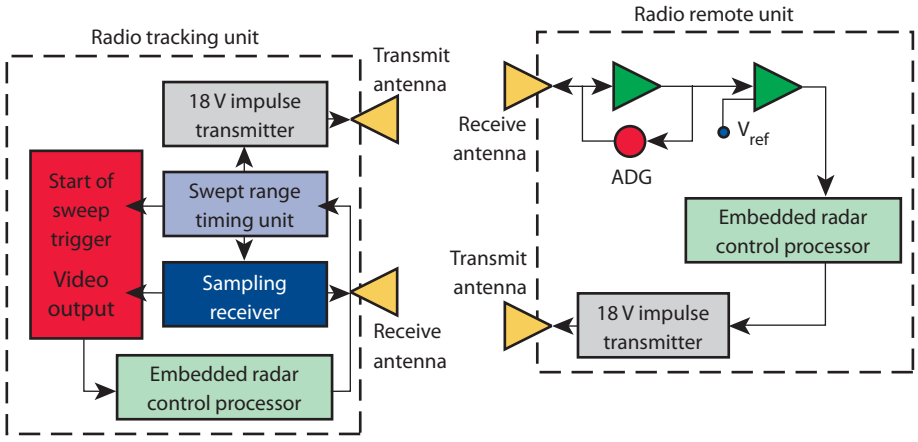

Figure 1. Block diagram of the round-trip TOF ranging pair, consisting of two units. The radio tracking unit sends a pulse to the remote unit, which replies with its own pulse. The main unit records the total round-trip TOF to extract the distance measurement.

urban environments is growing, and LLNL's established technology in MIR UWB radios and signal processing allows us to be at the cutting edge.

FY2006 Accomplishments and Results

In FY2006, we added the capability to support ranging and communication between multiple tracking and remote radio units, permitting the 3-D location of multiple units simultaneously. To accomplish this task we first added data-encoding capabilities into the UWB ranging transaction that the radios previously used. Then we uniquely identified the radar tracking and remote units so they can be addressed individually. Finally we implemented and embedded a Time Division Multiple Access (TDMA) protocol scheme so multiple units could co-exist in the same environment, without interfering with each other's ranging and communications transactions.

Figure 1 shows the updated hardware component diagrams; Fig. 2 shows their ranging transaction. For that transaction, the radio tracking unit sends an encoded pulse stream to the target radio remote unit. The remote unit receives the request and responds with its own uniquely encoded reply. The tracking unit receives and time-stamps the reply to find elapsed round-trip travel time, and thus distance. Distance measurements from multiple tracking radios can then be combined to compute a 3-D position estimation. A set of the complete remote and tracking hardware units can be seen in Fig. 3.

Using this completed system we have tested and documented the ranging performance in several harsh environments, supporting other LLNL projects, including the United States Coast Guard ships and subterranean caves.

Related References

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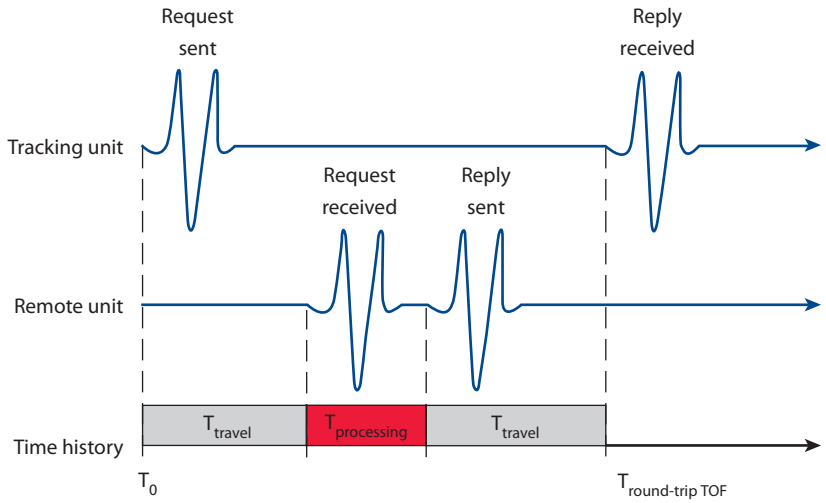

Figure 2. The round-trip TOF, consisting of travel time to and from the remote unit (approximately equal) and time spent in processing at the remote location (a known value we can subtract).

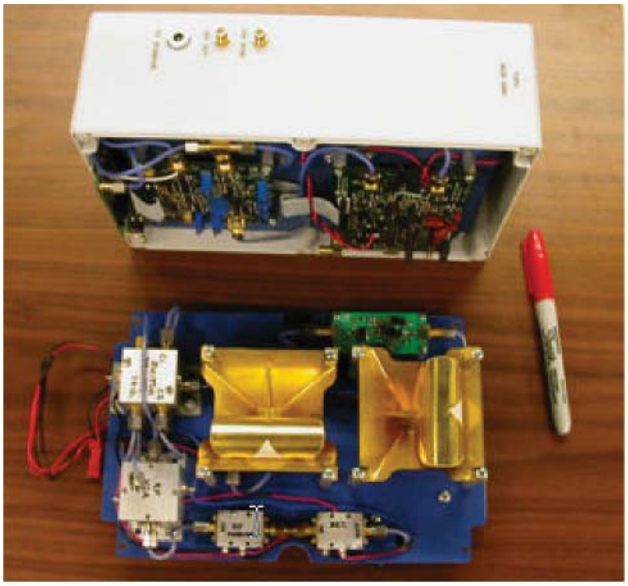

Figure 3. Completed UWB remote geo-location unit (top) and tracking radio (bottom).